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Be the Fairest of Them All: Challenges and Recommendations for the Treatment of Gender in Occupational Health Research

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Background *Both women's and men's occupational health problems merit scientific attention. Researchers need to consider the effect of gender on how occupational health issues are experienced, expressed, defined, and addressed. More serious consideration of gender-related factors will help identify risk factors for both women and men.*
Methods *The authors, who come from a number of disciplines (ergonomics, epidemiology, public health, social medicine, community psychology, economics, sociology) pooled their critiques in order to arrive at the most common and significant problems faced by occupational health researchers who wish to consider gender appropriately.*
Results *This paper describes some ways that gender can be and has been handled in studies of occupational health, as well as some of the consequences. The paper also suggests specific research practices that avoid errors. Obstacles to gender-sensitive practices are considered.*
Conclusions *Although gender-sensitive practices may be difficult to operationalize in some cases, they enrich the scientific quality of research and should lead to better data and ultimately to well-targeted prevention programs.* Am. J. Ind. Med. 43:618–629, 2003.

KEY WORDS: gender; sex; women; men; research methodology; epidemiology; ergonomics; confounding; effect modification; gender-based analysis

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INTRODUCTION

Both women's and men's occupational health merit scientific attention. In the United States, women constitute 46% of the paid workforce [United States Department of Labor, 2002], and have one third of compensated occupational health and safety problems, resulting in 81% of claims on a per hour basis [McDiarmid and Gucer, 2001]. These injuries entail direct and indirect costs to workers and employers, as well as human suffering [deCarteret, 1994]. Therefore, appropriately including sex and gender is increasingly relevant for occupational health research. Although researchers are interested in developing studies involving these variables, they may not know exactly how to do this. This article supplies some suggestions.

Many of the arguments presented here will apply to other sources of socially defined diversity such as age, race/ethnicity, and social class [Krieger et al., 1993; Kilbom et al., 1997; Wegman, 1999; Chaturvedi, 2001]. Each of these factors has its own interactions with the work environment and health effects, but their discussion is beyond the scope of this paper.

We have identified three types of problems in the way occupational health research has dealt with sex and gender. First, *hazards in women's work have been underestimated* [Rosenstock and Lee, 2000; Bäckman and Edling, 2001; London et al., 2002; McDiarmid and Gucer, 2001]. Women have been less often studied by occupational health scientists [Zahm et al., 1994; Messing, 1998a; Niedhammer et al., 2000]. Under-reporting and under-compensation, recognized problems in occupational health [Biddle et al., 1998; Davis et al., 2001; Harber et al., 2001], may be more of a problem for women [Lippel and Demers, 1996; Gluck and Oleinick, 1998].

Second, *although male workers have been relatively well studied, their experience has not often been examined in relation to their gender* [Kjellberg, 1998]. For example, there is an excess of occupational accidents among males, and there may be preferential assignment of jobs with high perceived risk to males [Salminen et al., 1992]. Social roles and expectations also shape men's experience of work and its effects, and deserve consideration from researchers [Courtenay, 2000].

Third, *gender has not always been treated appropriately in studies of mixed populations* [Dumais, 1992; Messing, 1992; Alexanderson, 1998a; Niedhammer et al., 2000; Punnett and Herbert, 2000]. Women and men have some differences in their biology, employment status, job and task assignments, and responsibilities and activities outside work, and all these may require adaptations of research protocols. ''Gender-sensitive'' or ''gender-based'' analysis is, therefore, being recommended as a way to target occupational health programs by getting more clearly defined data [Morris, 1997; Kilbom et al., 1998]. Such analysis looks at data by gender in order to put health indicators in the context of the different experiences and exposures of women and men [Health Canada, 2000]. Some research organizations, particularly in the social sciences, have developed guidelines for the consideration of gender in research [Denmark et al., 1988; Eichler and Lapointe, 1992]. In the US and Canada, medical researchers receiving federal funding are required to include women in studies. However, compliance has not been perfect [Ramasubbu et al., 2001], perhaps because researchers are not clear on the scientific importance of considering sex and gender. In this review we describe some ways that gender can and has been handled in studies of occupational health, as well as some of the consequences. We also suggest specific research practices that avoid errors.

Recent research has concentrated on the inadequate treatment of women's occupational health issues; we will also emphasize improvement in this area.

RELEVANCE OF SEX AND GENDER

Sex or Gender?

The Committee on Understanding the Biology of Sex and Gender Differences of the U.S. Institute of Medicine defines sex as ''the classification of living things generally as either male or female, according to their reproductive organs and functions assigned by the chromosomal complement,'' and gender as ''a person's self-representation as male or female, or how that person is responded to by social institutions. . .'' [Wizemann and Pardue, 2001, p 1].

Job Assignments and Exposure Differences

Occupational health scientists are interested in relating health to exposures at work, and these often differ by gender. In many countries, men are a majority of workers in primary or secondary sectors of the economy such as forestry, fishing, manufacturing, while women are in the majority in the service or tertiary sector [United States Department of Labor, 2002; Alexanderson and Östlin, 2001; Statistics Canada, 2002b]. Job segregation still exists. In Canada, only one occupation (retail sales clerk) is found in the lists of top ten jobs of both men and women [Statistics Canada, 2001].

Even within the same job title, men and women may be assigned to different tasks [Messing et al., 1994; McDiarmid et al., 2000] and be exposed to different working conditions. For example, women in retail sales in Europe more often sell cosmetics and shoes, while men more often sell automobiles and electronic equipment [McGauran, 2000]. In the US, women in sales are typically retail sales clerks, whereas men are often manufacturers' representatives [Blau et al., 2002: 138]. As occupation codes are given in more detail, differences between women's and men's tasks become more evident [Leijon et al., 2002]. These task assignments may translate into different exposures to toxic chemicals [London et al., 2002], ergonomic demands [Silverstein et al., 1986], risk of accidents [Salminen et al., 1992], and psychosocial stressors [Hall, 1989].

Further, due to differences in anthropometric measurements, even the same jobsite is not experienced the same way by men and women of average size. Tool design, working surface height, and equipment dimensions may make very different demands on the body, depending on workers' dimensions [Courville et al., 1991, 1992; Stevenson et al., 1996; Punnett and Bergqvist, 1999]. When height and size are factored in, apparent gender differences in workplace health problems may disappear [Stetson et al., 1992; Dumais and Courville, 1995].

Beyond job content, there are gender differences in workplace climate. Men's position in the hierarchy translates into more autonomy and control at work [Hall, 1989; Bourbonnais et al., 2000], characteristics that have been associated with a lowered risk for heart disease [Schnall et al., 1994; Bosma et al., 1997; Brisson et al., 1999] and better self-rated health [Ibrahim et al., 2001]. Women are more apt to be exposed to sexual discrimination at work, including sexism and sexual harassment [Arcand et al., 2000; Gutek, 2001], associated with a wide range of adverse physical and mental health outcomes [Fitzgerald et al., 1997].

In some cases, female sex can be protective. For example, male cleaners or hospital orderlies may be asked more often to do high-risk operations such as heavy lifting, even when unrelated to their job description [Messing et al., 1998b; Messing and Elabidi, 2003]. Men are more often exposed to chemicals, forceful exertions, and vibration [Silverstein et al., 1986; Arcand et al., 2000].

There are also gender differences in employment status and hours worked. Men work more total paid hours, more overtime, and more night shifts [Matte, 1998; Conseil du statut de la femme, 2000]. Women's and men's unemployment rates are similar in the United States, Sweden, and Canada [Organisation for Economic Co-operation and Development (OECD), 2000], but two to three times more women work part-time [Statistics Sweden, 1998; Statistics Canada, 2002f: p. 6]. It may be thought that part-time work corresponds to a lower ''dosage'' of workplace stressors, but, in many organizations, part-time workers are brought in at peak periods and experience work intensification and lower control over their work. On the other hand, working part time by choice, especially in higher-wage occupations, may have positive benefits [Barnett and Goreis, 2000].

Men are concentrated toward the top of the job hierarchy. In the US in 2002, men represented 84.3% of the corporate officers of the Fortune 500 companies [Catalyst, 2002]. In Canada, men are 54% of the work force but 80% of senior managers [Statistics Canada, 2001]. Women's annual salary for full-time, full-year work is on the average 71.7% of men's in Canada [Statistics Canada, 2002c] and 73.8% in the US [United States Department of Labor, 2002].

Their specific assignments result in different exposure profiles for women and men, which can often explain differences in rates of compensation for work-related illness or injury [Gluck and Oleinick, 1998]. In particular, many jobs held by women are less likely to involve acute traumatic injury or toxic exposures, and more likely to involve those associated with chronic, slowly developing conditions such as musculoskeletal problems or stress-related illness [Andersson et al., 1990; Wagener et al., 1997]. In the US, men experienced 67% of work accidents and illnesses and 92% of fatalities. Much of the female excess in musculoskeletal disorders may be due to differential ergonomic exposures, such as more repetitive work and less task variety [Punnett and Bergqvist, 1999; Punnett and Herbert, 2000]. Women workers' lesser degree of control over their environment may influence their health through the frequency of rest breaks, ability to position tools, equipment, and work surfaces, and ability to vary tasks over time.

Differences in Responses to Occupational Exposures by Gender

Many factors outside work can condition a worker's reaction to working conditions. Employed married women report doing more housework on average than their male counterparts (20.8 vs. 7.8 hr/week) [Blau et al., 2002: 57]. Women's typical domestic tasks (child care, elder care, laundry, cooking, and cleaning) differ from men's (home and car repair and maintenance) [Statistics Canada, 2002d,e] as do their recreational activities [Matthews et al., 2001]. These differences may cause fatigue or non-occupational stress, which in turn may affect reactions to workplace conditions [Bergqvist et al., 1995; Brisson et al., 1999].

Schedules often pose serious problems for those responsible for care of family members [Prévost and Messing, 2001]. Many childcare programs only provide services during regular working hours, and some kinds of jobs require travel which is very difficult for those with young children.

Male–female differences in education, socialization, and upbringing may lead to differences in the way workers manage their illnesses [Alexanderson, 1998b], their perception of risk [Gustafson, 1998], and the propensity to take sick leave or to seek treatment [Alexanderson et al., 1994, 1996; Doyal, 2001]. Women's work-related sick leave lasts longer on the average than men's [Feeney et al., 1998; Katz et al., 1998; Islam et al., 2001]. Several possible determinants can be hypothesized: women may heal more slowly due to domestic responsibilities or to differences in treatment. Men may perceive more pressure to go back to work quickly. Women may have less opportunity to adjust their work demands to their health status, less access to modified duties following injury [Stock, 1997], and less access to rehabilitation programs [Alexanderson and Östlin, 2001]. In addition, the health care, workplace health promotion, and workers' compensation systems appear to treat men and women differently [Lippel and Demers, 1996; Biddle et al., 1998; Lippel, 2000; Lagerlöf and Menckel, 2001].

Differences in Responses to Occupational Exposures by Sex

Biological differences between the sexes may affect responses to workplace toxins. For example, bone, fat, and immune system metabolism as well as cardiovascular and endocrine function are all known to differ by sex [Wizemann and Pardue, 2001: chapter 5]. Little, however, is known about the implications of these differences for the effects of toxic exposures [Setlow et al., 1998]. A number of studies suggest sex or hormone-mediated differences in muscle, tendon, and ligament biology (reviewed by Punnett and Herbert, 2000), which could affect the interactions between worksite architecture, work processes, and musculoskeletal problems. Sex has been associated with various measures of heart function [White et al., 1996; Hayward and Kelly, 1997; Hayward et al., 2001], and with responses to exercise and to thermal stress [Bar-Or, 1996; Perrault, 1996], although many unknowns remain.

RECOMMENDATIONS FOR IMPROVING OCCUPATIONAL HEALTH RESEARCH

Clearly, sex and gender are important influences on work-related exposures and health outcomes, and there are gaps in our knowledge concerning these influences. The following are suggestions for filling the gaps.

Choice and Wording of the Research Question

At this first stage, *it is important to be sure that both sexes are included in the research question where possible and appropriate*. Biological sex differences, for example in toxin metabolism, should be studied. The reasons for any differences found should be explored, carefully distinguishing exposures from other sex- or gender-specific characteristics. Even where the research is not primarily concerned with gender, such as in studies of toxic effects, failure to include only one sex, to assess effects appropriately for one sex, or to realize that exposures and reactions vary by sex will impair the quality of data on the more general research question (see below).

Consideration of gender is more complex than just including and comparing men and women. The way a question is asked may be more appropriate for one sex. Given the very limited evidence on women's occupational health, and on some aspects of men's occupational health, the research question should be phrased, if possible, so as to include topics, themes, and circumstances relevant to both sexes. Both men's and women's experience should be included. For example, studies of musculoskeletal problems might include elements of the work experience that encourage men to over-exert themselves, or that discourage them from seeking medical attention [Cru and Dejours, 1983; Kjellberg, 1998; Doyal, 2001].

At the same time, it is important to avoid assuming that some questions are relevant to one gender and not the other. For example, Bond et al. [2002] found that sexism at work affected the job satisfaction of both men and women. Gender-relevant questions can be asked of all-male, mixed, or all-female populations.

A promising way of ensuring that questions relevant to both sexes have been included is to consult men and women workers while designing the research question [Mergler, 1987, 1999; Garrigou et al., 1995; Loewenson et al., 1995; Keith et al., 2001; Messing and Seifert, 2001]. It may be relevant to consult workers in separate groups according to age, sex, and/or race in order to encourage disclosure of discriminatory practices and other specific experiences.

Study Design

In designing studies, the difficulty posed by sex segregation in the workplace should be addressed. Sampling strategies are chosen, in principle, as a function of the research question. However, in occupational health studies, populations are often determined by access constraints. Such populations may be skewed in favor of one sex, given the sexual division of labor. When sex and gender are not the subject of study and information on the total population is desired, it may be desirable to over-sample one sex in order to get adequate information. If there is difficulty attaining an ideal sample composition, many of the disadvantages of inadequate sampling can be mitigated by a thorough description of the study population, allowing the reader to understand the limits to generalization.

This problem often arises where numbers are limiting, as with jobs that are non-traditional for one sex. Some of the choices involved can be seen in a study of cancer incidence among workers in a fertilizer plant [Block et al., 1988]. Among the 3,400 workers were 173 women, who were eliminated from the sample due to small numbers. However, high rates of illness were found in a subsample of 38 men in a specific department where exposures were intense, and these data were presented. The women had apparently been eliminated before the high-exposure jobs were determined. Given the frequent sexual division of labor in factories, it is possible that some proportion of the 173 women were clustered in some jobs with high exposure. In such cases, in order to determine whether data on a minority sex should be examined, one must consider the geographic, hierarchical, and functional distribution of the workers of that sex in relation to the exposures considered, the posited physiological pathways, and the statistical power to demonstrate the relationships under investigation. If most of the women were office staff quartered in a building far away from the fertilizer handling, for example, it might be justifiable to exclude that group from some analyses. However, in that case the reason for exclusion would be expected exposure level and not sex.

Where numbers permit, it is desirable to compare men and women in closely similar situations. Often, when this is done, apparent male–female differences in work-related health conditions are diminished [Mergler et al., 1987; Emslie et al., 1999; McDiarmid et al., 2000; Punnett and Herbert, 2000].

Many occupational studies compare selected working populations to the total or ''general'' population, which is made up of working and non-working persons, including people too sick to work. However, to a greater extent than among men, employed women differ from unemployed women in terms of age, marital status, family socioeconomic status, fertility, drug use, alcohol consumption, health insurance, access to medical care, and other factors [McMichael, 1976; Kryston et al., 1983; Herold and Waldron, 1985; Roman et al., 1985; Sorlie and Rogot, 1990]. In addition, the ''healthy worker effect'' operates differently for women and men [McMichael, 1976; Herold and Waldron, 1985; Sorlie and Rogot, 1990; Lea et al., 1999]. The above factors may confound comparisons of mixed working populations with the general population.

Choice of Variables

The variables chosen in relation to the research question should include enough information so that exposures and outcomes can be accurately described for each gender. In order to do this, exposures should be well characterized and should ideally go beyond job title [Burstyn and Kromhout, 2000; London et al., 2002]. This procedure, although costly, would help avoid the problem of exposure misclassification that often diminishes researchers' ability to demonstrate exposure–effect links [Dosemeci et al., 1990]. Relevant variables may include not only work contexts and exposure variations that differ by gender but also policy and practice relating to stereotyping, discrimination, and family-friendliness. These variables may be relevant to research questions not only on work organization and psychological outcomes but also on chemical or ergonomic exposures, since some groups may be concentrated in specific parts of the work process or certain shifts with specific exposure characteristics.

Efforts must be made so that the terms or variables used have the same meaning for both sexes. For example, in public buildings in Canada the same job title (cleaners) translates to different tasks for women and men [Messing, 1998b]. The same family situation (e.g., having children under 10 years of age in the home) will translate differently for women and men into hours of paid and unpaid work (men with families do more overtime paid work, women do more unpaid work).

The quality of information available on the two sexes must be considered. Death certificates may contain the occupation and industry at the time of death or the ''usual'' (longest-held) occupation and industry. If women are not actively employed outside the home at the time of death, ''housewife'' may be entered even if they previously held long-term full or part-time paid employment [Steenland and Beaumont, 1984; Gute and Fulton, 1985]. Even when those designated as housewives are excluded, the accuracy of information on women's certificates is less than that on men's certificates [Schade and Swanson, 1988]. (Risks associated with housework and selection bias related to reasons for being at home require full consideration elsewhere.)

A special attempt must be made when dealing with the differential relationships between age, race, social class and exposure for women and men [Krieger et al., 1993; Wegman, 1999; Krieger, 2000]. For example, how should the occupation/income of one spouse be taken into account when describing the social class of the other [Sorensen, 1994; Krieger et al., 1997; Sacker et al., 2001]?

In order to understand what variables are relevant to describing exposure, it is often necessary to gather qualitative data through preliminary interviews and observation of the workplace [Needleman and Needleman, 1996]. A thorough qualitative study can inform the choice of variables for a quantitative study [Mergler, 1999].

Research Instruments

Exposures should be measured where possible rather than being deduced from job title. As noted above, this is true for exposures relevant to toxic effects as well as musculoskeletal disorders.

Care must be taken so that research tools used are appropriate for both sexes. This involves various precautions, such as validating instruments for both male and female populations. For example, the widely used Job Content Questionnaire was derived in all-male populations, and only later validated with female populations [Pieper et al., 1989; Schnall et al., 1990; Kawakami and Fujigaki, 1996; Ibrahim et al., 2001]. Some parameters important for women such as responsibility for others' welfare, discrimination [Bond et al., submitted], and family-friendly policies [Messing, 2000] were not included.

Orhede and Kreiner [2000] developed a new instrument to assess exposures in the psychosocial work environment. They found that, even though total scores on the instrument did not differ by sex, for almost all items used there was significant evidence of item bias, implying that the instrument did not work in the same way for men and women.

The applicability of items to subjects may vary considerably between the sexes. In developing a Neck and Upper Limb Index to measure functional status, researchers found that numerous potential items were relevant for one sex but not the other (e.g., difficulty vacuuming: applicable to 94% of women but only 20% of men) [Stock et al., 1995]. A disadvantage for men might occur in tests of dexterity if the same size objects are manipulated by both sexes without regard to the large differences in hand size [Hayward and Griffin, 2002], and women are at a disadvantage in strength tests designed for taller people [Stevenson, 1995; Stevenson et al., 1996].

At the same time, different criteria for men and women should be used only with caution. For example, in scoring one instrument for depression, a higher threshold was applied to women than to men, to avoid a presumably excessive prevalence of depression in women [Goldberg et al., 1996]. The study found associations with workplace conditions for men and not for women. However, it cannot be ruled out that the higher criterion resulted in underestimation of women's depression and occupational risks.

In some cases, validation of a test or even of individual items may not be enough. We can ask whether using an instrument derived with one sex and then validated with another will include sufficiently all variables most important to the second sex. Might an increase in explained variance be achieved by adding items more closely related to the experience of the other group? To address this issue and generate the full complement of appropriate potential items for a new scale, researchers need to interview sufficient numbers of male and female members of the targeted population during the development phase of the instrument.

Data Analysis—Confounding and Interactions

Sex should rarely be treated as a confounder. A confounder is a factor that produces a spurious association between an outcome and an exposure. It does so by being associated with both exposure and outcome, without being in the causal pathway that links the two, and by being incompletely controlled for in analyses. For example, if women in the general population are more likely to suffer from a disease and there are more women in an exposed than a control population, researchers often control for sex, hoping to separate out the effects of exposure. However, if women (or men) have higher rates only because they are concentrated in specific jobs that put them at risk, then female sex is associated with disease only because women are more exposed [Mergler et al., 1987; Mergler, 1995]. In this case sex is not a confounder, because it does not have an independent relationship to disease risk along a separate causal pathway. It is a proxy for exposure-related variables. Controlling for sex would therefore result in underestimation of a true exposure–effect relationship.

Too often, the ease of applying methods such as multivariate regression modeling may lead the investigator to overlook the question of whether or not age, race, and gender should be treated as confounders. Interactions with risk factors should always be assessed before confounding is considered and, if interaction is found, analysis should be carried out separately for the different strata [Kleinbaum et al., 1998: chapter 11]. However, even modeling of interaction terms is not sufficient where the sexual division of labor is pronounced. In a study of poultry processing workers, controlling for sex concealed exposure–effect relationships among women and men that appeared when the sexes were studied separately [Messing et al., 1998a]. In a first strategy, data from women and men were analyzed together from the beginning, controlling for sex, and, in a second, data from women and men were analyzed separately from the beginning (Table I). The final models were totally different: four factors were retained for women, one for men, and two for both sexes. Of the five risk factors that emerged from the single-sex analyses, only two had been retained in the combined model; no risk factor retained for women was also retained for men and sex was not retained. In this database, interaction terms between sex and exposure were not statistically significant, largely because sexual segregation was so great that insufficient numbers appeared in some categories.

A related problem, known as intra-stratum confounding, could occur from treating sex as a possible risk factor where other, differentially distributed risk factors have been dichotomized. If levels of continuous exposures are associated with gender and the levels are categorized too broadly, the sexes may be differentially distributed within categories. Adjusting for sex results in over-adjustment, since it may be thought of as subdividing the exposure categories. This was the case, for example, in a study of respiratory and other symptoms associated with indoor air quality [Skov et al., 1989]. Environmental exposures were significantly associated with symptoms, as was being female. Exposure to more than 25 sheets of carbonless paper per day was significantly associated with symptoms. However, according to Stenberg and Wall [1995], women are more likely to manipulate carbonless copy paper. If the women studied by Skov et al. were clustered toward the upper end of the category

TABLE I. Final Models for "at Least One Absence for Respiratory Problems" Among Workers in Poultry Slaughterhouses and Canneries in France

Exposure	Model derived for female workers	Model derived for male workers	Model derived for both sexes
Gas	**3.1 (1.2–7.8)**	0.9 (0.3–2.7)	1.5 (0.8–3.0)
Cold, humidity, drafts	**2.2 (1.3–3.9)**	1.4 (0.5–3.4)	**2.1 (1.3–3.3)**
Temperature $<9°C$	0.8 (0.4–1.2)	**3.0 (1.6–5.7)**	1.2 (0.8–1.9)
Dissatisfied with work relations	**0.2 (0.1–0.9)**	0.8 (0.2–2.7)	0.4 (0.2–1.1)
Children <6	**2.3 (1.4–3.6)**	1.3 (0.7–2.4)	**1.7 (1.2–2.5)**
Female sex	—	—	1.3 (0.9–1.9)

From Messing et al. [1998a].

"exposure to more than 25 sheets of copy paper," a not unreasonable supposition, sex would spuriously appear as an additional risk factor. However, if exposure had been classified in more detailed categories, sex might have disappeared as a predictor. (Without access to the data set, we cannot examine this possibility.)

Separate analyses can yield important hypothesis-generating results for both sexes. For example, the fact that women's and men's lung function showed differential changes in relation to exposure to refractory ceramic fibers led Lemasters et al. [1998] to ask questions about the biology of lung function, as well as the chronology of the healthy worker effect in their population.

Consequences of a stratified analysis for the statistical power of analyses cannot be ignored, however. It may be impossible, with attainable sample size, to arrive at adequate stratified analyses that take into account the different influences of gender, race/ethnicity, and age. In fact, looking at the two sexes separately may result in apparent differences that may be the result of differential sample sizes. This possibility should always be considered and commented on where appropriate. For example, one study of occupational exposure to diesel engine emissions and risk of cancer was able to access 7,400,000 person-years of exposure for men, but only 240,000 for women [Boffetta et al., 2001]. The abstract reads, in part, "Men exposed in the 1960 census experienced an increased risk of lung cancer: the relative risks (RRs) were 0.95 (95% confidence interval [CI] 0.9–1.0), 1.1 (1.1–1.2), and 1.3 (1.3–1.4) for low, medium, and high intensity of exposure. . . .Results in women were not suggestive of an effect (RR in the category of medium or high intensity of exposure 1.1, 95% CI 0.6–1.8)." However, the effect for women was of about the same size as for men, even though the small numbers greatly widened the confidence interval.

When health outcomes of women and men are examined, the differences in hours worked should be considered and analyses adjusted accordingly [Messing et al., 1994; Islam et al., 2001]. For example: if work accidents of women and men are compared as accidents per employee per year, the proportion of accidents among women will probably be underestimated. This proportion will rise if it is calculated as accidents per hour worked, since women on the average work fewer hours per year than men, even among "full-time" employees. Attention should also be given to the effects of including or excluding maternity/paternity leaves in calculating absence and accident rates.

Nor can it be presumed that non-occupational covariates behave similarly for both sexes. For example, marital status does not have the same implications for extraprofessional sources of fatigue among women and men. In a Brazilian bank, being married was significantly and positively associated with chronic fatigue measured by the Chalder scale, but only for women [Souza et al., 2002]. Examining the effect of marital status for both sexes together would have obscured these differences.

Data Analysis—Correcting for Biological Differences

Use of correction factors by sex must be carefully considered and justified by reference to data. When biological data on reactions to the workplace are being analyzed, it is customary to introduce correction factors by sex where these have been calculated. For example, in analyzing data on the effects of mercury exposure, investigators used slightly different factors to calculate creatinine clearance for women and men [Frumkin et al., 2001]. In analyzing data on heart rate elevation during work, investigators (ourselves among them) have been tempted to correct for different resting level heart rates for women and men. Using this kind of correction based on sex-typing can be unwise, since the correction factors may incorporate some of the phenomena being studied. A male–female difference in resting heart rate may possibly reflect different levels of activation in response to different life conditions. In such a case, individual resting heart rates would not be well represented by an aggregate value attributed according to sex. It is important to explore the proposed mechanism for putative sex differences in metabolism, in order to apply the appropriate correction. In some instances, this could be an individually based variable, such as body size or percent body fat. In other cases, sex might well be a good surrogate measure for levels of a specific hormone.

Interpreting and Reporting Results

Sex of subjects should be reported. In many publications in occupational health, results are reported in such a way that the sex of subjects cannot be ascertained. For example, the summary of an article entitled "Quantitative morphology of the human foot in a North American population" begins, "A comprehensive series of variables that describe the essential three dimensional characteristics of the human foot is presented together with descriptive statistics derived from a diverse civilian population (N = 1,197) representing a wide age range (18–85 years) and randomly selected in terms of physical demands placed upon the foot in the course of a normal working day" [Hawes and Sovak, 1994]. It is impossible to tell from the title or abstract that the study included only men, and in fact the language used makes it appear that a wider sample was studied. In some cases, the sex composition of a sample cannot be ascertained even from the full paper, although the list of occupations or industries may lead the reader to assume that the sample is entirely male [e.g., Lee et al., 2001]. This was the case for 40 of 348 papers examined by Niedhammer et al. [2000] in six major occupational health journals in 1997. With modern methods of data searching, the wording of titles and abstracts becomes increasingly important.

Interpretations of findings should acknowledge limitations of the data set and study methods that may affect the conclusions regarding male–female differences. This is particularly important since analyses of how epidemiologic data are used in North America have shown that researchers' conclusions are an important source of justification for tribunals to accept or refuse compensation cases [Lippel, 1999; Lippel et al., 1999] as well as for legislation and regulation. Researchers must take care not to imply that sex or gender causes a health problem if this does not correspond to the research findings. Gender differences should be reported carefully, expressing both means and variance so that the extent and importance of differences are neither minimized nor exaggerated, and so that possible mechanisms are revealed [Blair et al., 1999].

Many researchers check their results with workplace informants before publication, in order to pick up possible errors or to hear explanations of results [Mergler, 1987; Guérin et al., 1997: chap. 12]. It is important to include all relevant groups in this validation process. Similarly, circulating draft manuscripts to a diverse group of colleagues can yield valuable feedback and foster exploration of alternative interpretations.

OBSTACLES TO CHANGE

Many factors work against the incorporation of gender in occupational health research. The most important is the difficulty of reconciling the need for detailed data on exposures and outcomes with the large sample sizes necessary for taking population diversity into account in a sensitive way. Gaining access to large workplaces is extraordinarily difficult, and detailed studies on such workplaces are expensive. Further research, it is hoped, will pinpoint the similarities between men and women and those areas where stratified analysis is absolutely necessary. In cases where there are too many important categories of populations to analyze (age, race/ethnicity, sex) and it is thought that these are linked to exposure and effects, qualitative analysis can often supply information not otherwise available. Tapping into the experience of workers can help explain the forces at play and the ways the effects of the workplace on workers may be influenced by gender, race, and age [Mergler, 1999].

In some jurisdictions, research priorities may be driven (directly or indirectly) by compensation regimes and other costs to employers. For example, in Québec, Canada, the Board of Directors of the research institute on occupational health and safety (IRSST) is identical to that of the Health and Safety Commission (compensation board). Research topics are largely determined by the likelihood of compensation, resulting in a propensity to study sectors with traditional, well-recognized risks. Overall, populations studied in 1999 included occupations or employment sectors averaging 15% female, although 45% of the Quebec labor force is female. Only eight of 86 studies included populations with more than 33% women [Messing, 2002]. If uncompensated health problems do not emerge in the statistics, there may be no funding for the relevant research that might better inform compensation decisions.

There may be ideological obstacles to gender-sensitive research. Consideration of gender issues is regarded as essential in social science, but there is no such tradition in the biomedical sciences. Consideration of gender (or racial) issues is sometimes rejected as ''contamination'' of science by the introduction of ''political'' issues. While the inherent subjectivity of research as a human and social activity has been thoughtfully described [Ratcliffe and Gonzalez-del-Valle, 1988; Muckler and Seven, 1992], not all researchers are willing to accept this position.

A related concern may be that the investigator, especially if she is female, may call her own objectivity into question or risk being pigeon-holed if she calls attention to such issues as gender differences in subjective experiences and gender-biased research instruments or interpretations of research findings. There may also be a fear that identification of women-relevant occupational health issues will interfere with attempts to gain equality in the workplace or that identification of gender-related issues will interfere with compensation of workplace-induced disease [Headapohl, 1993]. These fears may be realistic, and contexts should be carefully established for the presentation of research results on such topics as sex differences in strength or effects of workplace agents on menstrual function [Messing, 1999].

CONCLUSIONS

The mission of occupational health research is to prevent disease and suffering among workers. Gender sensitivity is a means to increase the effectiveness of research in accomplishing this goal. We have shown that gender sensitivity is more than comparing men's and women's disease and injury rates. It is a re-examination of workplace reality that imposes changes in the usual way of proceeding in order to improve the quality of information about male and female workers. We believe these are necessary changes that will lead to better-targeted prevention programs for both sexes.

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range of data from Statistics Canada can be obtained from Statistics Canada's Regional Offices, its World Wide Web site at http://www.statcan.ca and its toll-free access number 1-800-263-1136.

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